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Study of freshmen in College of Engineering in effort to explore some of the factors which contribute to satisfactory achievement. Correlations among high school rank, entrance test scores, and grades received in both semesters are reported. These correlations, though generally significant, are low for accurate prediction of achievement in individual cases.

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Engineering Education Research
Engineering Experiment Station
College of Engineering
University of Wisconsin
Madison, Wisconsin

May, 1959

A Study of Achievement in the Freshman Year in the College of Engineering University of Wisconsin 1957-1958

The entrance test scores, high school rank, and grades received during the first and second semesters for freshmen entering the College of Engineering of the University of Wisconsin in September, 1957, have been analyzed in order to explore some of the factors which contribute to satisfactory achievement in the College of Engineering. The present study includes only those freshmen who were taking the typical program of studies for first year engineering students, i.e., Chemistry 2a or 4a, Mathematics 51, English 1a, and Drawing 12 in Semester I, and Chemistry 2b or 4b, Mathematics 52, English 1b, and Drawing 23 in Semester II. Data for 219 students were complete for the first semester, and for 123 students for both Semester I and II.

Entrance test scores were available in these areas:

English Placement Test: English Recognition Test
University of Wisconsin

Mathematics Placement Tests: Cooperative Intermediate Algebra Test-Form Z
Cooperative Plane Trigonometry Test-Form Y

Pre-Engineering Ability Test - Form ZPA

College Qualifications Tests - Combined Booklet Edition, with part scores for Numerical, Information, Verbal, & Total.

Product-moment correlation coefficients were calculated between entrance test scores, decile rank in high school class, grades for first semester subjects, and grade point average for Semester I. These correlations are presented in Table 1. For a population of 200, a correlation of 0.138 is significantly different from zero at the 5% level of confidence, and a coefficient of 0.181 is significant at the 1% level of confidence (2, p. 331).

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Table 1. Product-moment correlations between entrance test scores, high school rank, first semester grades, and grade point average for 219 typical freshmen entering the College of Engineering, University of Wisconsin, September, 1957. * indicates significance at 5% level, ** indicates not significant. All other correlations are significantly different from zero at the 1% level of confidence.

	Engl.	Pre-Engr.	CQT-V	CQT-I	CQT-N	CQT-Tot	HSR-dec	GPA-I	Gr-Chem 2a or 4a	Gr-Engl 1a	Gr-Math 51	Gr-Dr 12	Alg.
Pre-Engr	.514												
CQT-V	.535	.490											
CQT-I	.344	.477	.482										
CQT-N	.397	.616	.250	.367									
CQT-Tot	.573	.656	.871	.776	.581								
HSR-decile	-.376	-.334	-.182	-.394	-.404	-.377							
GPA-I	.396	.344	.209	.280	.478	.371	-.487						
Gr-Chem 2a or 4a	.398	.318	.186	.337	.466	.375	-.420	.768					
Gr-Engl 1a	.234	.340	.169*	.191	.352	.276	-.275	.657	.493				
Gr-Math 51	.604	.472	.437	.348	.463	.535	-.425	.621	.445	.455			
Gr-Draw 12	.220	.227	.078**	.154*	.409	.222	-.408	.865	.641	.470	.403		
Alg.	.281	.447	.169*	.222	.443	.317	-.120**	.236	.262	.173*	.238	.200	
Trig.	.250	.455	.138**	.323	.450	.338	-.152*	.246	.262	.128**	.272	.165*	.635

Abbreviations: Engl = English Recognition Test
Pre-Engr = Pre-Engineering Ability Test
CQT-V, I, N, Tot = College Qualification Tests, Verbal, Information, Numerical, Total - part scores
Gr-Chem, Engl, Math, Dr = Grade in Chemistry 2a or 4a, English 1a, Mathematics 51, Drawing 12 - taken Sem I
= " " " 2b " 4b, " 1b, " 52, " 23 - taken Sem II
HSR-dec = Decile rank in high school
GPA-I = Grade point average, Sem I, where A=4, B=3, C=2, D=1, F=0. GPA-II = Grade point average, Sem II
Alg = Coop Intermediate Algebra. Trig = Coop. Plane Trigonometry

Product-moment correlation coefficients were also calculated between the above mentioned variables and second semester grades and grade point averages. These correlations are presented in Table 2. The calculations are based on a population of 123 typical freshmen who completed Semester II (1957-58), having taken the usual second semester courses, i.e., Mathematics 52, Chemistry 2b or 4b, Drawing 23, and English 1b. For a population of 125, a correlation of 0.174 is significantly different from zero at the 5% level of confidence, and a correlation of 0.228 is significantly different from zero at the 1% level of confidence (2, p. 331).

The correlations reported in Table 1 are generally of the same order as those reported in the literature concerned with prediction of success in engineering. Where the correlations differ in magnitude, it is felt that they are lower because of restrictions placed on the sample, as when students who were not enrolled in the typical courses and who did not complete the first semester were eliminated from the calculations. Stuit et al. (10, pp. 27-33) report a median correlation coefficient of .42 when scores on tests of scholastic aptitude are correlated with first year scholarship for engineering students. Further, median correlation between first year records and mathematics achievement tests is reported as .56. Stuit also cites correlations between decile rank in high school class and first semester grades of .58. Moore (9, p. 512), reports a correlation of .68 for first semester weighted course grades and the Pre-engineering Ability Test. This is higher than the correlation reported in Table 1 for University of Wisconsin engineering freshmen.

Layton (5, pp. 26-27), summarizing results of research conducted during the past 25 years, confirms the reports of Stuit et al (10). He summarizes these reports as follows, "In researches attempting to predict grades, one rarely finds coefficients of correlation above .60 between single predictors and school marks."

Table 2. Product-moment correlations between entrance test scores, high school rank, first and second semester grades, grade point averages for Sem I, II, and over-all first year for 123 typical freshmen in the College of Engineering, University of Wisconsin, September, 1957.
* indicates significant at the 5% level of confidence. ** indicates not significant. Other correlations are significantly different from zero at the 1% level of confidence.

	GPA-Tot	GPA-I	GPA-II	Chem 2a	Dr 12	Engl 1a	Math 51	Chem 2b	Dr 23	Engl 1b	Math 52	HSR	CQT-Tot
GPA-Sem I	.862												
GPA-Sem II	.969	.739											
Gr Chem 2a, 4a	.778	.732	.729										
Gr Draw 12	.447	.489	.376	.205*									
Gr Engl 1a	.333	.525	.210*	.234	.193*								
Gr Math 51	.802	.834	.710	.583	.322	.264							
Gr Chem 2b, 4b	.792	.621	.798	.773	.230	.111**	.574						
Gr Draw 23	.685	.515	.720	.463	.439	.095**	.458	.439					
Gr Engl 1b	.394	.327	.400	.268	.122**	.320	.265	.180*	.159**				
Gr Math 52	.861	.621	.907	.585	.305	.127**	.649	.630	.568	.249			
HSR	-.412	-.427	-.375	-.360	-.109**	-.236	-.378	-.353	-.190*	-.284	-.265		
CQT-Tot	.238	.327	.174*	.302	.019**	.496	.176*	.162**	-.018**	.355	.079**	-.399	
CQT-V	.101**	.185*	.062**	.150**	-.042**	.495	.033**	.004**	-.082**	.408	.009**	-.210*	.874
CQT-I	.229	.295	.167**	.329	.044**	.290	.171**	.240	-.028**	.174*	.092**	-.455	.761
CQT-N	.332	.375	.271	.276	.149**	.256	.366	.249	.197*	.054**	.204	-.331	.487
Engl	.256	.316	.211*	.239	.093**	.462	.158**	.114**	.066**	.374	.168**	-.295	.512
Pre-Eng	.265	.297	.207*	.194*	.271	.354	.151**	.159**	.175*	.134**	.119**	-.353	.584
Alg	.390	.389	.342	.310	.234	.254	.355	.328	.225*	.072**	.285	-.270	.461
Trig	.231	.300	.165**	.243	.087**	.185*	.198*	.212*	.098**	-.071**	.122**	-.216*	.336

Note: For abbreviations see Table 1.

Section I

second semester grades,
n the College of Engi-

Other correlations

Engl 1b	Math 52	HSR	CQT-Tot	CQT-V	CQT-I	CQT-N	Engl	Pre-Eng	Alg
249									
284	-.265								
355	.079**	-.399							
408	.009**	-.210*	.874						
174*	.092**	-.455	.761	.431					
054**	.204	-.331	.487	.178*	.323				
374	.168**	-.295	.512	.503	.295	.253			
134**	.119**	-.353	.584	.403	.483	.526	.324		
072**	.285	-.270	.461	.274	.310	.653	.224*	.574	
071**	.122**	-.216*	.336	.117**	.377	.445	.136**	.460	.468

Section 2

(5, p. 26) Layton reports coefficients of about .45 between engineering grades and scholastic aptitude tests, with mathematics aptitude tests in particular correlating about .50 to .55 with grades in engineering.

Although correlations between entrance test data and high school rank and achievement are generally statistically significant, prediction of first year achievement in the College of Engineering lacks a high degree of precision where these indicators are used to predict for an individual student. Correlations reported for the 1957-58 freshman class are, in some instances, lower than those reported in the literature, but it is felt that this is a result of the limitations placed upon the sample used, and differences in the tests employed.

The records of the (1957-58) freshmen were analyzed in yet another way to try to glean additional information about factors related to achievement in the College of Engineering. The records for the freshmen were divided into groups according to the academic action recorded for the students at the end of the first semester. The categories were:

(N) No action taken, i.e., satisfactory completion of first semester with grade point average of C or better.

(P) Placed on probation, i.e., has obtained a grade point average of less than C, but has passed more than $\frac{1}{2}$ the credits for which he is enrolled.

(D) Dropped, i.e., has not passed more than half the credits for which he has enrolled in any one semester, or, if already on probation, has not obtained a C average in the succeeding semester.

(T) Transferred to another college, either on the Madison campus or elsewhere.

Means and standard deviations for high school rank and entrance tests were calculated for each of the groups and are presented in Table 3.

Table 3. Means and standard deviations on high school rank and test scores for students who continued with no academic action, on probation, who were dropped for academic deficiency, or who transferred to another college.

Index	Mean Standard Deviation	(N) No Action	(P) Probation	(D) Dropped	(T) Transferred
High school rank (decile)	M.	2.12	3.83	4.14	1.60
	S.D.	1.61	1.78	1.55	0.95
CQT-total	M.	150.54	137.90	130.86	150.67
	S.D.	18.00	17.62	20.53	15.70
CQT-verbal	M.	50.34	45.44	44.57	50.20
	S.D.	11.45	11.05	13.45	10.60
CQT-information	M.	57.19	53.54	53.14	57.07
	S.D.	7.06	6.50	4.85	6.35
CQT-numerical	M.	42.96	38.71	33.57	43.27
	S.D.	4.63	5.44	8.16	3.28
English	M.	105.67	96.46	99.71	105.87
	S.D.	10.91	12.93	15.67	12.18
Pre-eng.	M.	49.24	42.81	41.29	51.00
	S.D.	8.97	9.37	10.96	6.70
Algebra	M.	63.03	61.35	60.29	63.33
	S.D.	6.19	4.14	2.37	3.11
Trig	M.	52.98	50.42	49.29	54.67
	S.D.	8.02	6.70	9.48	5.96
Number of students		144	48	7	15

The null hypothesis of no difference in mean score on entrance tests or high school rank between the groups on the above indices was postulated, and appropriate statistical calculations were made. Results are tabularized on the following page.

	No action	Transferred	Dropped
Probation	HSR CQT-Total -Verbal -Information -Numerical English pl Pre-eng. pl * Algebra * Trigonometry	HSR * CQT-Total CQT-Numerical * English pl * Trigonometry	No significant difference.
Dropped	HSR * CQT-Total CQT-Numerical * Algebra	HSR * CQT-Total * CQT-Numerical * Algebra	
Transferred	HSR		

The listed mean differences between groups were found to be significant at the one per cent level of confidence except where indicated by an asterisk. An asterisk indicates that mean differences are significant at the five per cent level of confidence. High school rank and CQT-total score would seem to be the best overall predictors of academic action taken at the end of the first semester. The differences in mean score between the group placed on probation and the group against whom no action is taken seem reliable on all the entrance data available.

In attempts to obtain maximum prediction of achievement in engineering colleges, combinations of various indices have been reported in the literature. Among these, Jones, (4, p. 295) found that the two best combinations for prediction of first semester and first year marks for Clark University freshmen in engineering were (1) Coop Math Test and high school grade point average (r=.64) and (2) Coop Chemistry Test and high school grade point average (r= .63).

McClanahan and Morgan (7) studied Colorado A&M students who had taken the ACE, Iowa Placement Chemistry Aptitude Test, Coop English, Nelson-Denny Reading Tests, and for whom high school rank was available. They found a multiple correlation of .85 between these indices and first year grade point average. Further,

they found a combination of the Chemistry and English scores was the best predictor of first year grades.

Eichsteadt and Pufahl (3), working with students most similar geographically to the University of Wisconsin College of Engineering group, have developed a regression equation predicting first semester grade point averages for University of Wisconsin-Milwaukee engineering freshmen. The equation they have developed utilizes high school rank and the percentile on the Ohio State Psychological Exam as factors in prediction. The Ohio State Exam is not given to University of Wisconsin-Madison freshmen, but might be regarded as having some similarity to the CQT-Total score, which is given.

Layton (5, pp. 27-28) summarizes the studies on combinations of indices by stating that, "Coefficients of multiple correlation in engineering studies have been reported ranging from about .40 to .85. In a majority of these studies high school average plus one or two tests, either aptitude or achievement, have received the most weight. The multiple correlations average about .65 in the reported studies."

In an attempt to increase predictive accuracy over that obtainable with single variables, the Numerical Analysis Laboratory set up multiple regression equations for prediction of grade point averages for freshmen in the first and second semesters in the College of Engineering, based on records for the 1957-58 freshman class. These equations are:

<u>Regression equation for prediction of first semester grade point average.</u>

$x'_1 = (-.1362)x'_2 + (.0421)x'_3 + (.0107)x'_4 + (-.0731)$

where x'_1 = predicted grade point average for the first semester

x'_2 = decile rank in high school graduating class

x'_3 = CQT-Numerical score

x'_4 = English placement test score

(N = 219)

Using this equation, the multiple correlation coefficient is .594. Using all eight placement test scores plus decile rank in high school, the multiple correlation coefficient is .597.

Regression equation for prediction of second semester grade point average.

$x''_1 = (-.1313)x''_2 + (.0094)x''_3 + (.0098)x''_4 + (.0669)x''_5 + (-2.1355)$

where x''_1 = predicted grade point average for the second semester

x''_2 = decile rank in high school graduating class

x''_3 = CQT-Verbal score

x''_4 = English placement test score

x''_5 = Algebra placement test score

(N = 123)

Using this equation, the multiple correlation coefficient is .472. Using all nine indicators, the multiple correlation coefficient is .475.

Regression equation for prediction of grade point average for first year.

$x_1 = (-.1093)x_2 + (.0059)x_3 + (.0559)x_4 + (-1.3488)$

where x_1 = predicted over-all grade point average, first year

x_2 = decile rank in high school graduating class

x_3 = English placement test score

x_4 = Algebra placement test score

(N = 123)

Using this equation, the multiple correlation coefficient is .513. Using the nine indicators available, the multiple correlation coefficient becomes .525.

To indicate the use and meaningfulness of these equations, several illustrative cases are presented below, showing grade point averages predicted from the above equations, and grade point average actually obtained.

	Predicted GPA	Obtained GPA
Freshman 001		
Semester I	2.95	3.44
Semester II	3.87	incomplete
Freshman 008		
Semester I	2.28	2.61
Semester II	3.02	2.16
First year	2.42	2.49
Freshman 026		
Semester I	2.92	3.83
Semester II	3.71	3.67
First year	2.83	3.75
Freshman 032		
Semester I	2.34	1.44
Semester II	2.74	1.27
First year	2.20	1.37
Freshman 051		
Semester I	2.27	2.39
Semester II	2.82	1.72
First year	2.38	2.06

As can be seen, accuracy of prediction for the individual case is in some instances fairly high, and in others, fairly low. Obviously, factors other than those measured by entrance test scores and rank in high school graduating class are operating where individual achievement is the measured variable.

In addition, multiple regression equations for the prediction of grades in Chemistry, Mathematics, English and Drawing have been prepared from the data by the Numerical Analysis Laboratory. These are not herein reported due to limitations of space. The equation for achievement in first year mathematics is discussed in an earlier report, "An Exploration of Factors Related to Achievement in First Year Mathematics.", which is available on request.

In an attempt to increase the accuracy of individual prediction, it was felt that the effect of the addition of personality variables such as needs, values, etc., into the multiple regression equation might profitably be investigated. Two personality tests were therefore administered to the freshmen entering the College of Engineering in September, 1958. These data plus the usual high school rank and entrance test scores will be submitted to analysis at the completion of Semester II, 1958-1959, when grade records for the first year are complete. It is planned to follow the 1958-59 freshmen throughout their careers in the College of Engineering in order to obtain the answers to questions which arise and will remain unanswered unless a long term study can be made of a single group of engineering students (8).

The writer has been in correspondence with researchers at this and other institutions who are studying prediction of academic achievement and persistence among engineering students by the addition of personality tests to various aptitude and achievement indices (1, 6). For example, Drake and Oetting (1) have studied the relation between a personality inventory and achievement in a University of Wisconsin freshman population. The writer would hope to find support for their conclusions, and relate the findings more directly to engineering students in the current study of the 1958-59 freshmen class.

To summarize, the typical freshmen from the 1957-58 class in the College of Engineering have been studied in an effort to explore the factors important to achievement. Correlations among high school rank, entrance test scores and grades received in Semesters I and II are reported. These correlations, though generally significant, are low for accurate prediction of achievement in an individual case. Multiple regression equations for the prediction of grade point average for the first and second semester are presented, with sample cases to illustrate their use and efficacy.

It is postulated that the addition of the personality variables measured for the freshmen class of 1958-1959 to these correlation matrices and multiple regression equations will maximize prediction, and in addition, provide some insight into the factors important to successful achievement of freshmen in the College of Engineering. These data will be reported as soon as records for the first year are complete for the 1958-59 freshman class.

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